

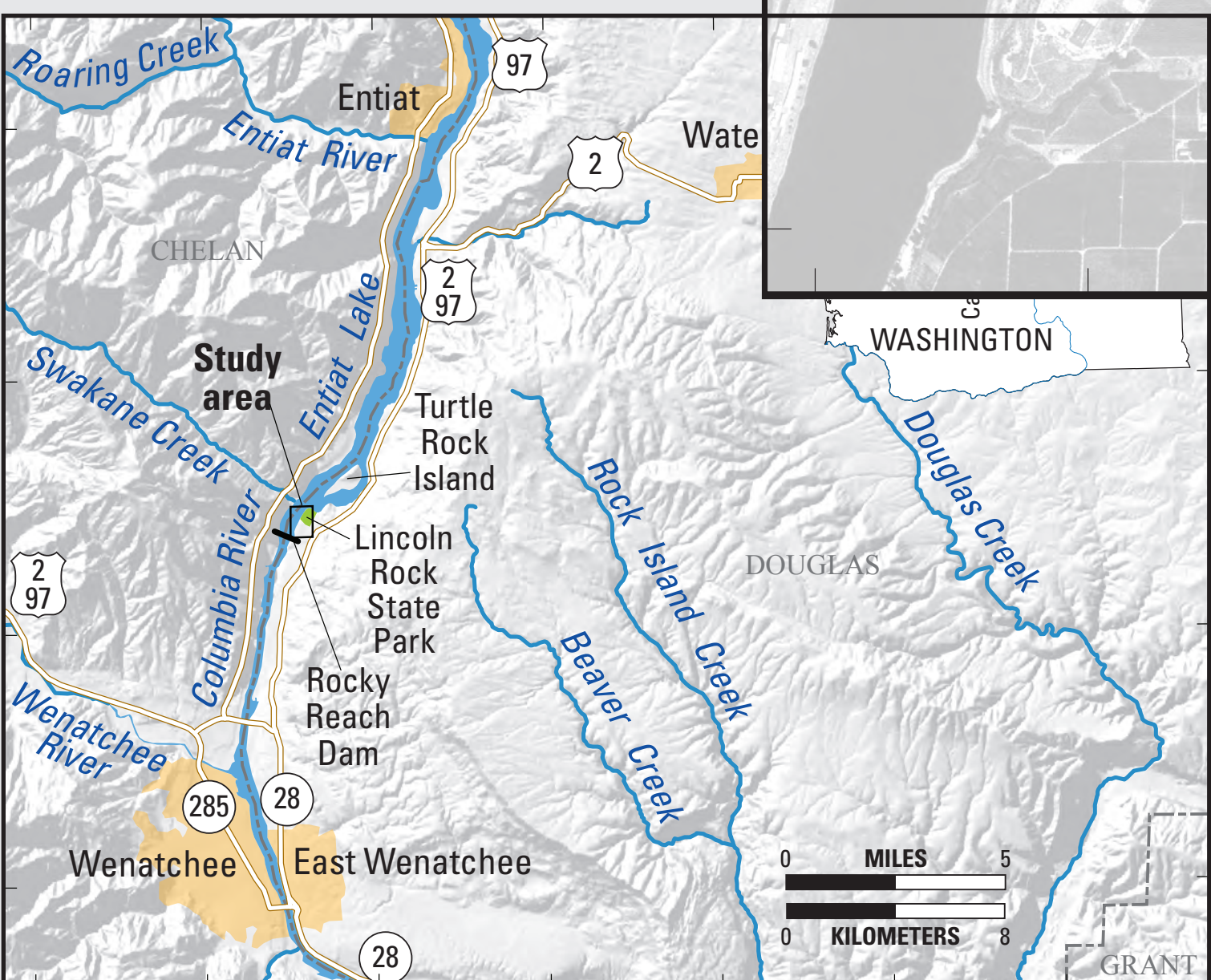
# Hydrologic and Thermal Conditions of the Eastbank Aquifer System near Rocky Reach Dam, Douglas County, Washington

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## Introduction

The Eastbank Aquifer system is located in a river-terrace deposit along the Columbia River upstream of Rocky Reach Dam. It is recharged primarily by the Columbia River and provides water to a fish hatchery and a regional water system serving the cities of Wenatchee, East Wenatchee, and parts of unincorporated Chelan and Douglas Counties. In 2006, mean annual pumpage by the hatchery (CT well field) was about 43 and 16 cubic feet per second (ft<sup>3</sup>/s) (19,000 and 7,200 gallons per minute, gal/min), respectively (van Heeswijk and others, 2008). Successful hatchery operation requires cool water for raising salmonid species and concerns over increasing groundwater temperatures were the reason for this study. The study objectives were improving the understanding of (1) the hydrologic and thermal conditions of the Eastbank Aquifer system and (2) the processes that affect those conditions. The study was conducted in cooperation with Public Utility District No. 1 of Chelan County (Chelan PUD).

### Study Location

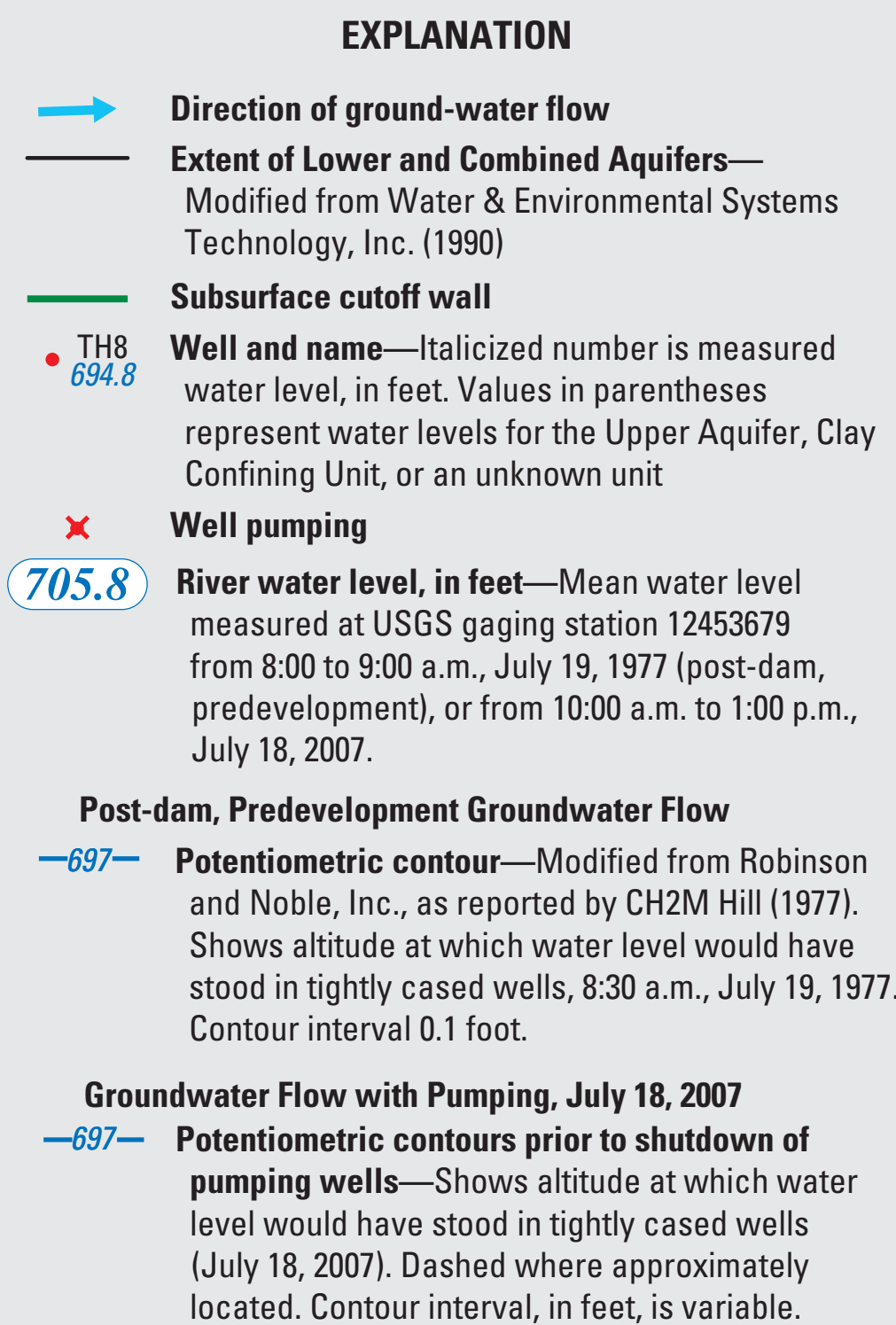
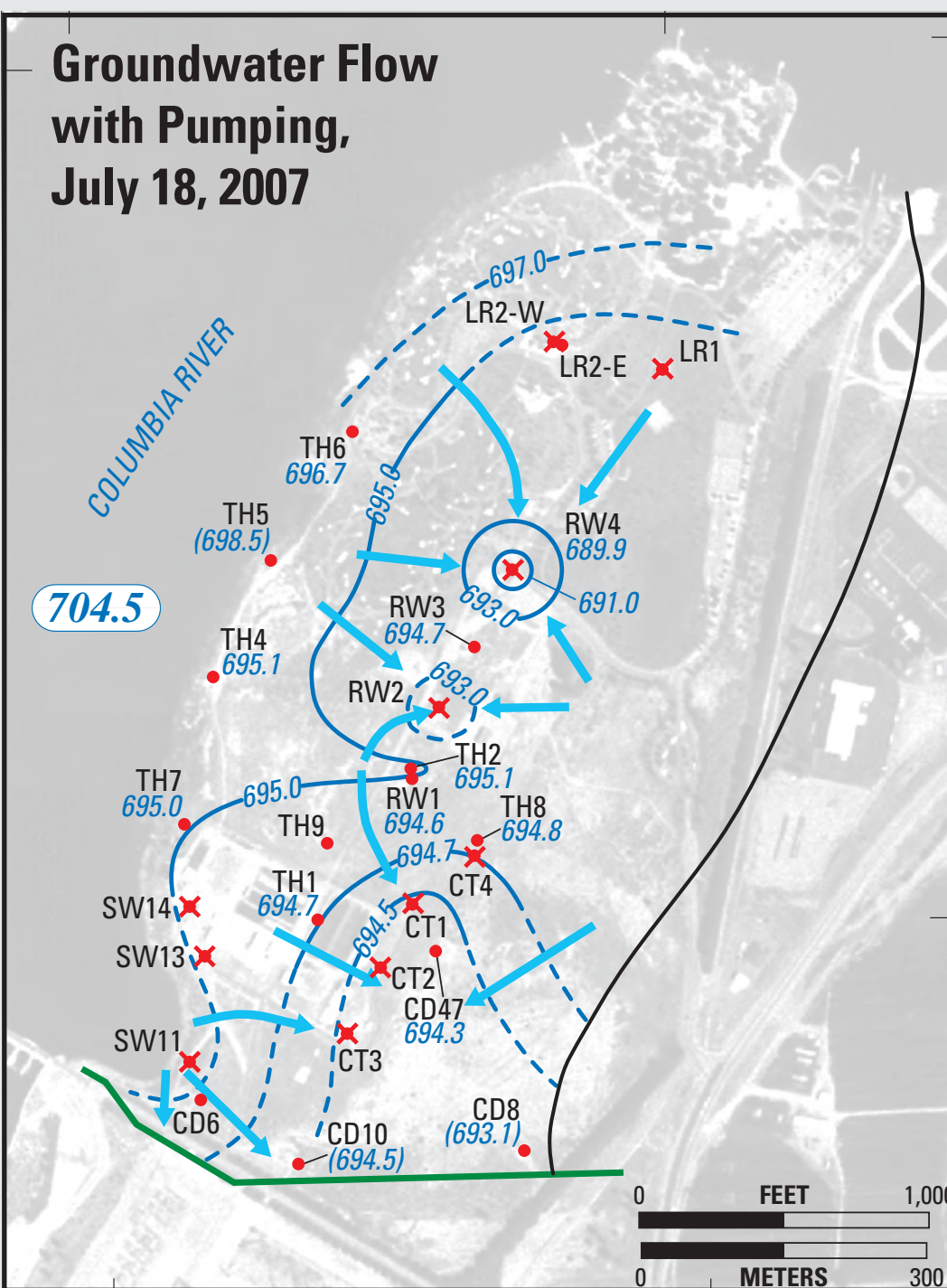
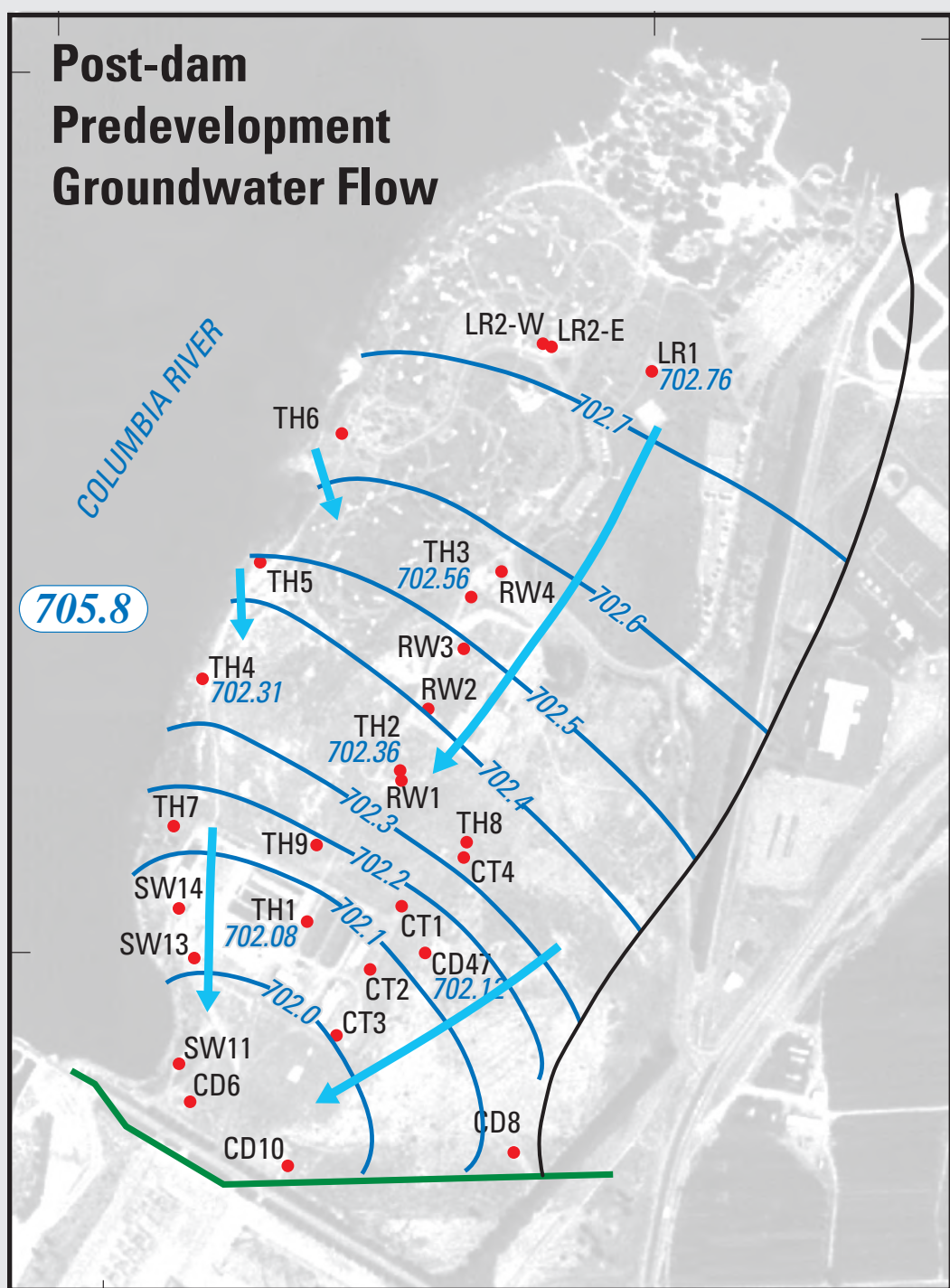
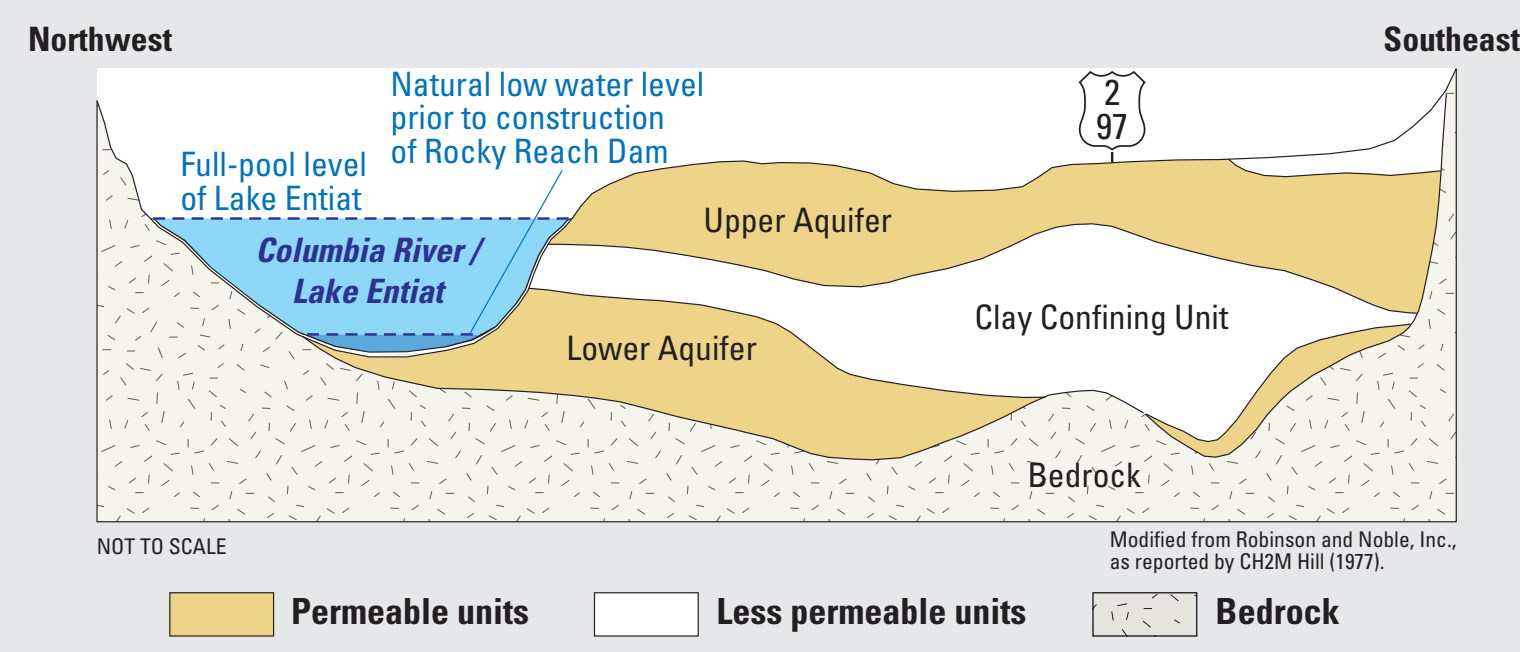


## Hydrogeologic Framework and Hydrology

The Eastbank Aquifer system consists of largely unconsolidated sedimentary units that overlay Late Cretaceous metamorphic bedrock of biotite gneiss (Tabor and others, 1987). The units form the Lower and Upper Aquifers (glaciofluvial gravels and sands) and the Combined Aquifer where the Clay Confining Unit (lacustrine silts and clays) is absent in the northwestern part of the study area. Groundwater pumpage is from the Lower and Combined Aquifers, which have very large transmissivities ranging up to 1,700,000 square feet per day (ft<sup>2</sup>/d) (Robinson and Noble, Inc., as reported by CH2M Hill, 1977).

The Lower Aquifer became a confined aquifer when the reservoir (Lake Entiat) formed at the completion of Rocky Reach Dam in 1961 and water levels in the river were raised almost 100 feet. A subsurface cutoff wall that extends east from the dam across the terrace deposits and down to bedrock maintains water levels in the Upper and Lower Aquifers, but some groundwater seepage occurs. Post-dam, predevelopment flow in the Lower and Combined Aquifers was generally parallel to the river, from northeast to southwest. With the pumping of large-capacity wells installed in 1983 (RW well field) and 1989 (CT well field), flow directions have changed toward the RW and CT well fields.

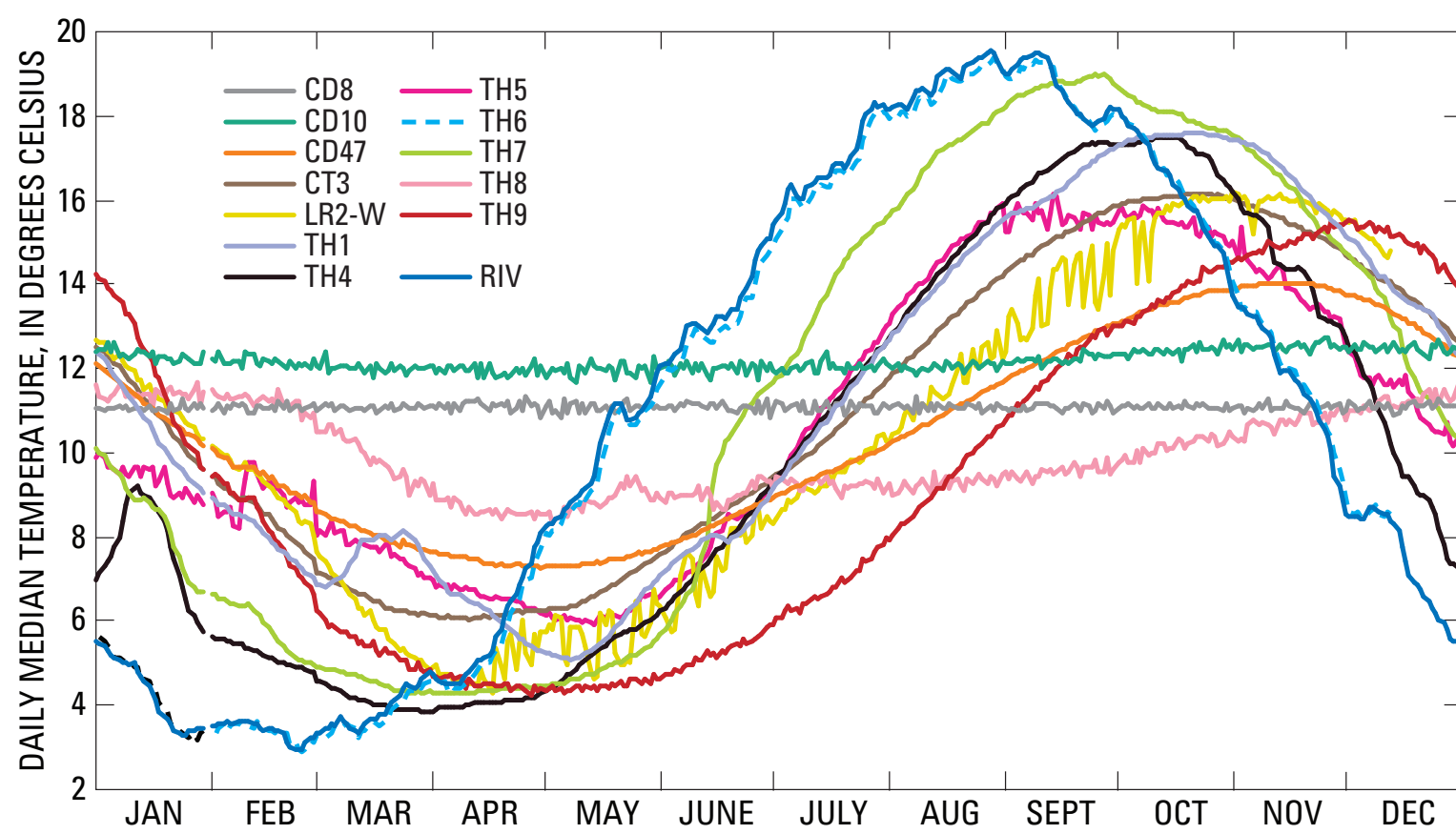
### Hydrogeologic Cross Section



## Historical Water-Level and Temperature Monitoring

The Chelan PUD has monitored water levels and temperatures in wells and the Columbia River (Lake Entiat) hourly since 1990. Limited verification of measurements and instrument drift made the accuracy of water levels uncertain and they were not analyzed for trends. Water temperatures were reliable and were analyzed.

### Well and River Temperatures, 2006

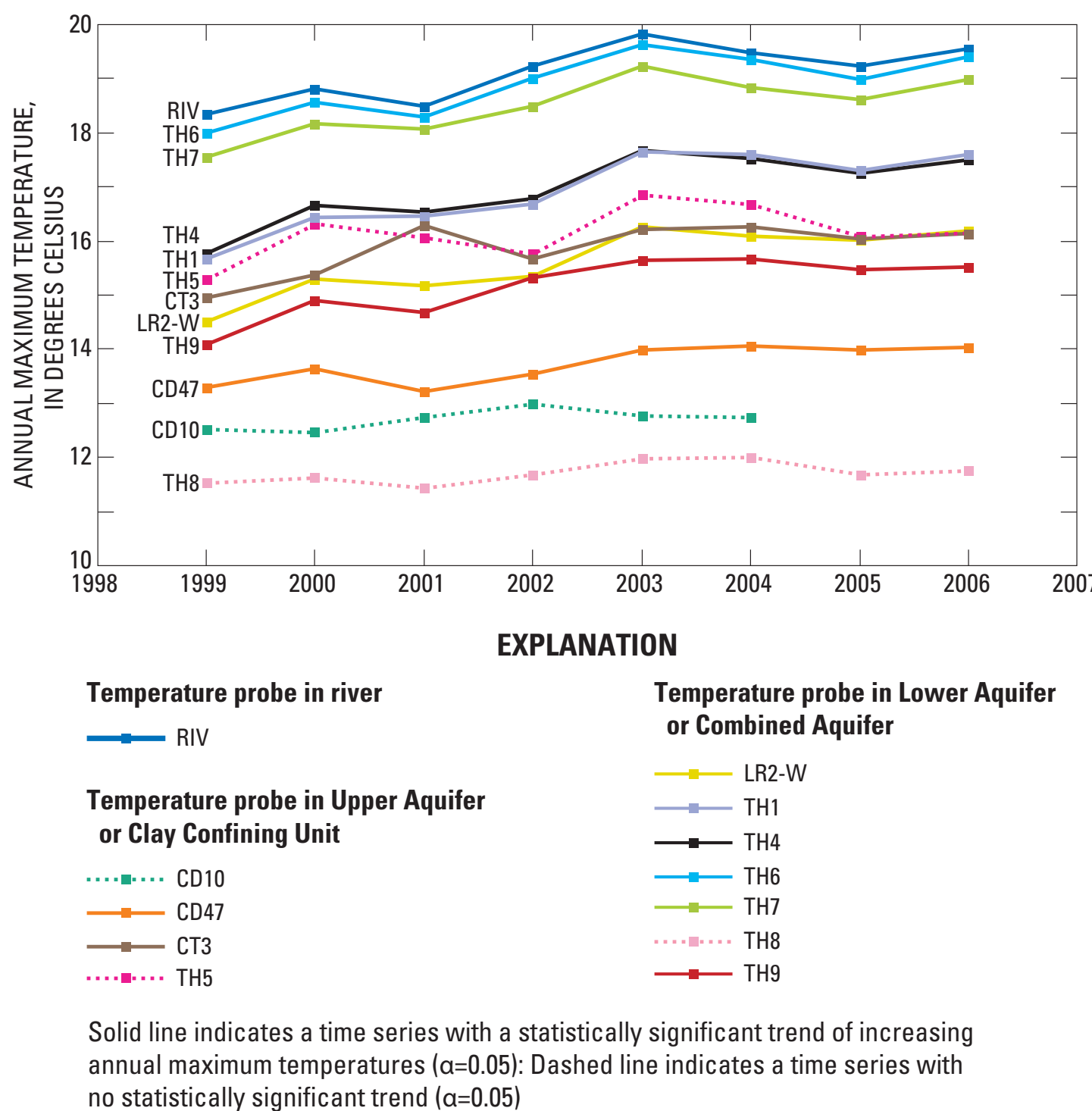


## Trends in Water Temperatures

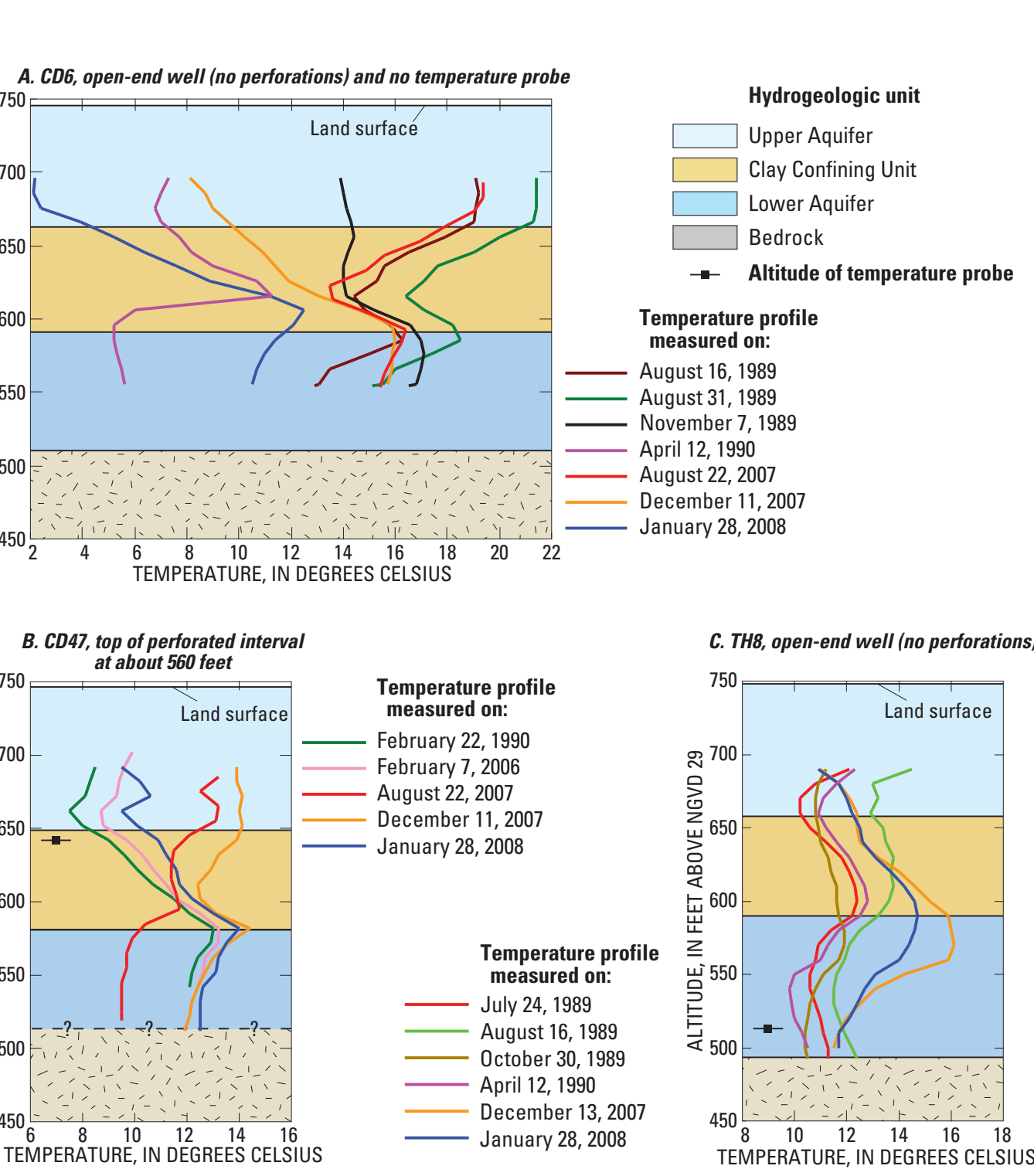
Most of the Lower and Combined Aquifers indicate increasing interannual trends in temperatures from 1999 through 2006 that correspond to increasing trends in the annual mean and annual maximum temperatures in the Columbia River of 0.07 and 0.17°C per year, respectively. These increases are within the natural variability of the river temperatures. There were no trends in the annual minimum river temperatures during the same period, and there were no trends in the annual minimum, mean, and maximum river temperatures from 1991 through 1998 and from 1991 through 2007.

Because most of the Lower and Combined Aquifers reached thermal equilibrium—defined by constant time lags between changes in river temperatures and subsequent changes in groundwater temperatures—prior to 1999 and seasonal pumpage patterns were relatively stable from 1999 through 2006, increasing interannual trends in groundwater temperatures are most likely explained by increasing trends in river temperatures.

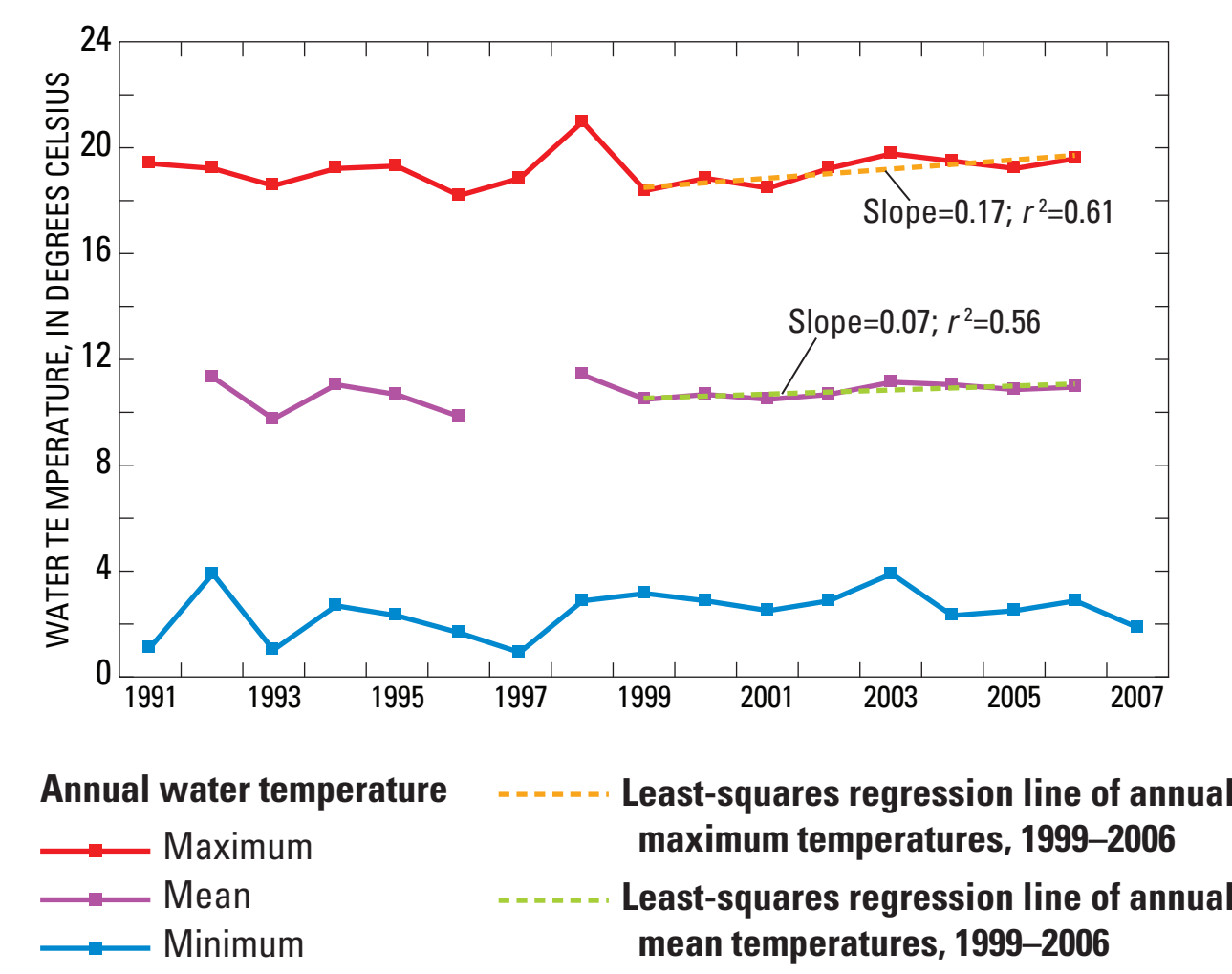
### Annual Maximum Well and River Temperatures



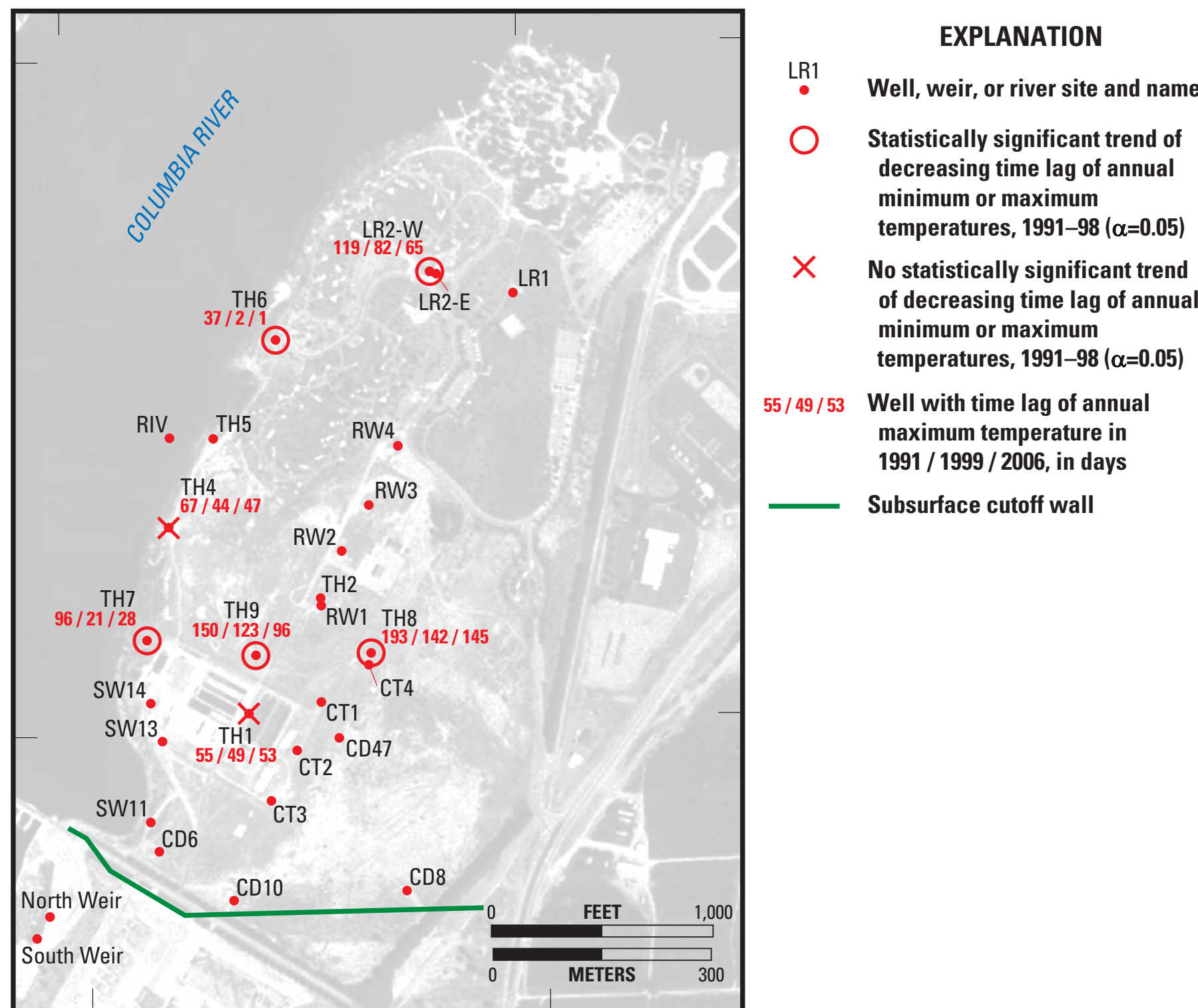
### Selected Vertical Temperature Profiles



### River Temperatures



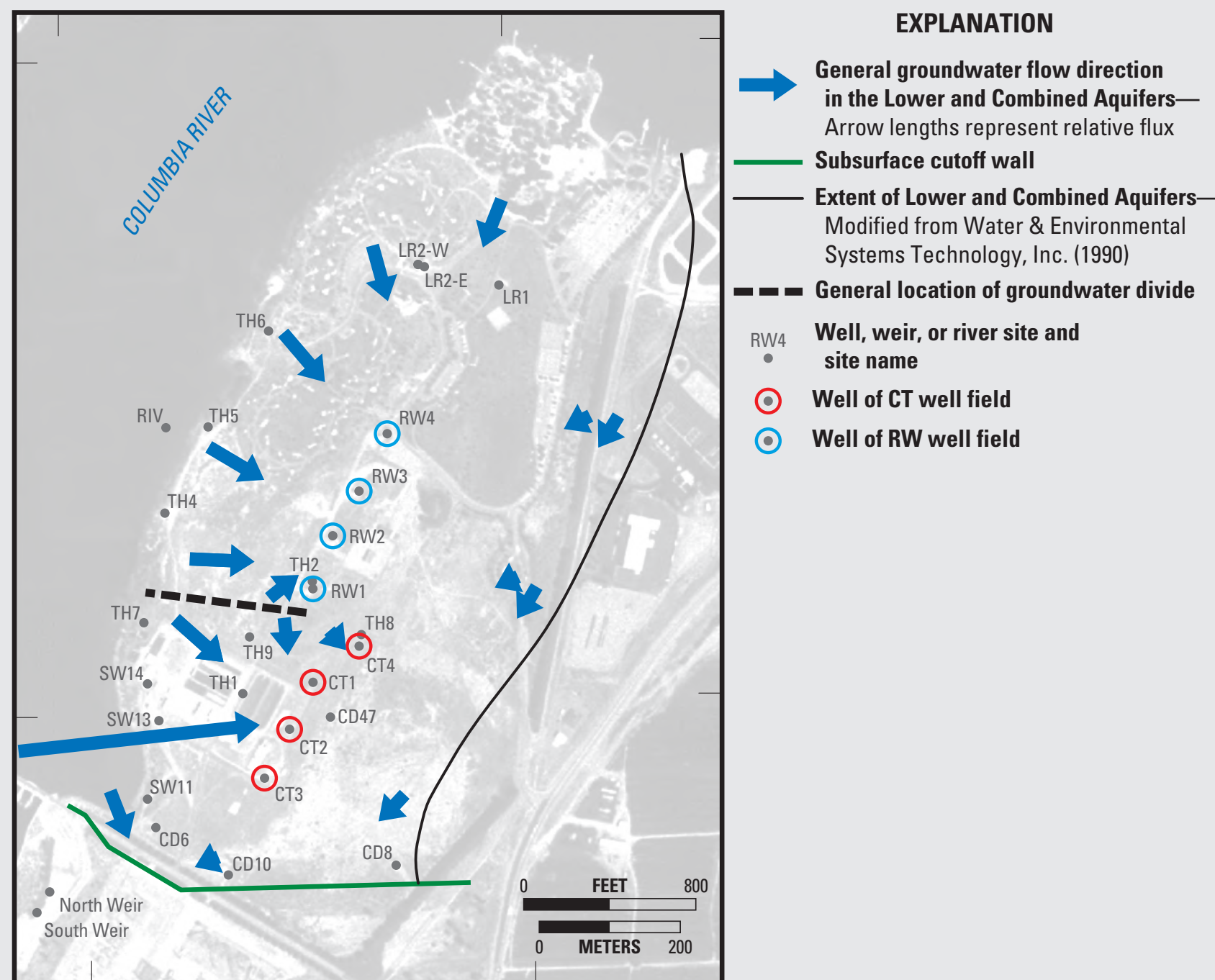
## Trends in Time Lags Between River and Well Temperatures



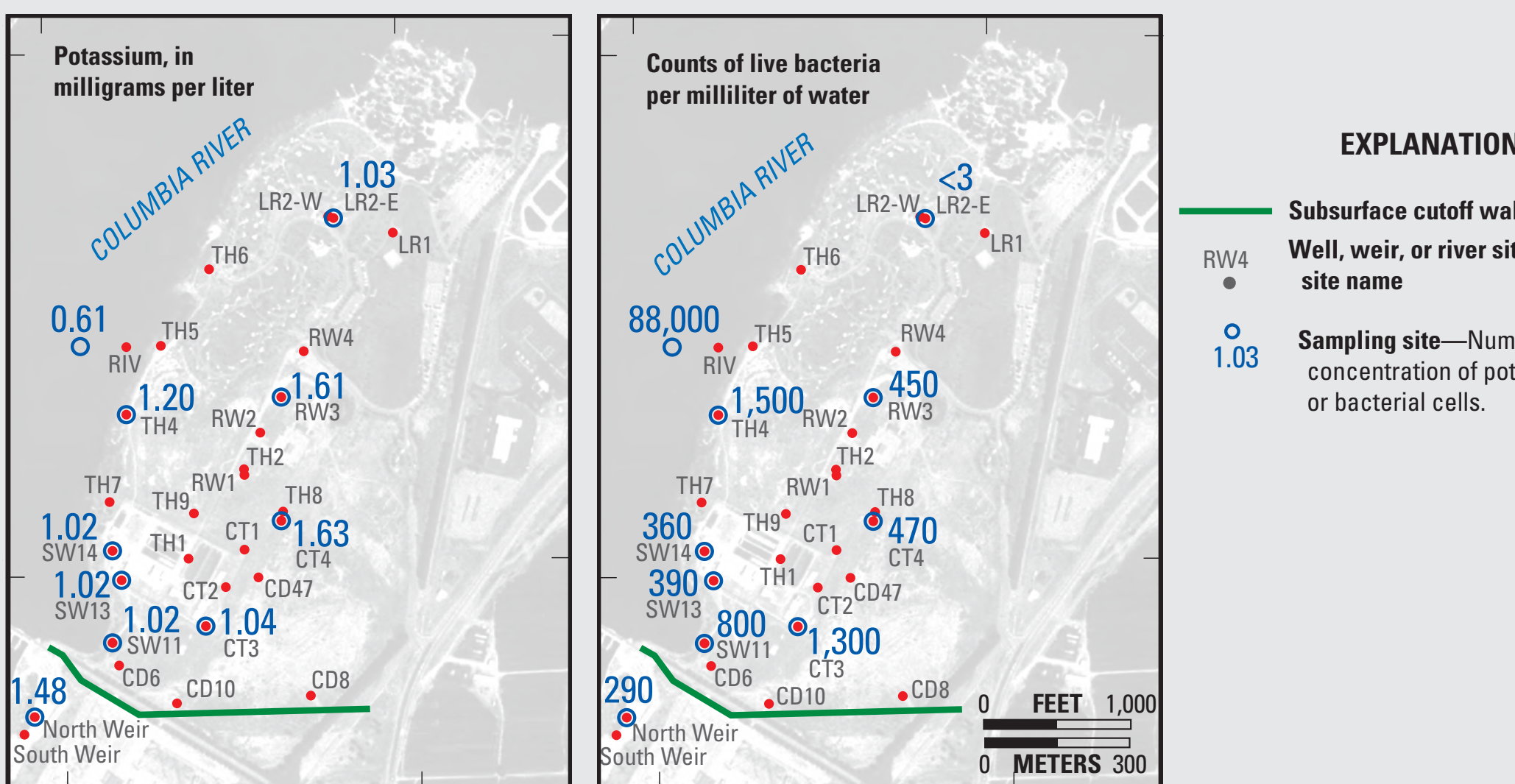
## Conceptual Model

Analyses of water-level data collected on July 18, 2007, and dissolved-constituent and bacterial concentrations in samples collected August 20–22, 2007, showed that most of the water pumped by the hatchery (CT well field) recharges along the river at the generally shortest distance between the well field and the river. In addition, analyses of the historical groundwater temperature data showed that at historical pumping rates, water pumped by the hatchery recharged about 2 months prior to the time it was pumped from the aquifer.

### Generalized Groundwater Flow Directions and Fluxes, 2007



### Distribution of Potassium and Live Bacterial Cells, August 20–22, 2007



## References Cited

- CH2M Hill, 1977, Wenatchee Regional Water Supply System predesign report (draft): Prepared for the City of Wenatchee, Washington, about 150 p.
- Tabor, R.W., Frizzell, V.A., Jr., Whetten, J.T., Waitt, R.B., Swanson, D.A., Byerly, G.R., Booth, D.B., Hetherington, M.J., and Zartman, R.E., 1987, Geologic map of the Chelan 30-minute by 60-minute quadrangle, Washington: U.S. Geological Survey Geologic Investigations Series I-1661, 1 plate.
- van Heeswijk, Marijke, Cox, S.E., Huffman, R.L., and Curran, C.A., 2008, Conceptual model of hydrologic and thermal conditions of the Eastbank Aquifer System near Rocky Reach Dam, Douglas County, Washington: U.S. Geological Survey Scientific Investigations Report 2008–5071, 66 p.
- Water & Environmental Systems Technology, Inc., 1990, Eastbank Hatchery pumping test and analysis, final report: Prepared for Public Utility District No. 1 of Chelan County, Wenatchee, Washington, about 200 p.

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